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(71)出願人　501387839
株式会社日立ハイテクノロジーズ
東京都港区西新橋一丁目24番14号

(72)発明者　枝村　学
茨城県土浦市神立町502番地　株式会社日立製作所機械研究所内

(72)発明者　池永　和幸
茨城県土浦市神立町502番地　株式会社日立製作所機械研究所内

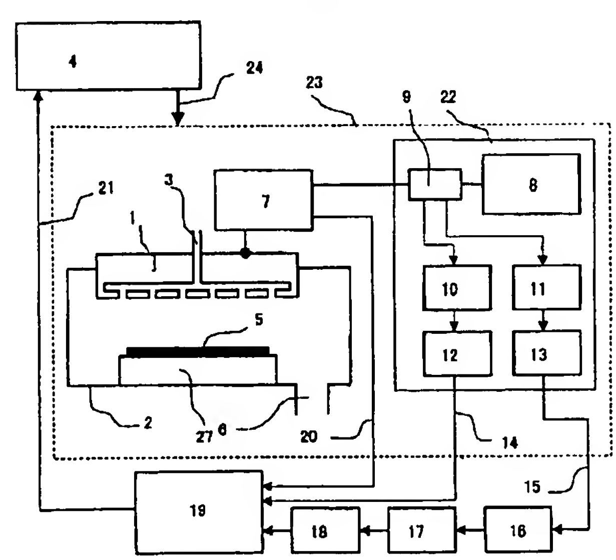
(74)代理人　100078134
弁理士　武　顕次郎

最終頁に続く

(54)【発明の名称】　プラズマ処理装置及び処理方法

(57)【要約】
【課題】異常放電発生時にプラズマ処理を停止してプラズマ処理不良の発生を防止する。
【解決手段】処理ガス導入手段３、排気手段６及び半導体ウエハを載置するウエハステージ２７を備えた真空チャンバ２と、該真空チャンバ２内に高周波電力を供給して前記真空チャンバ内にプラズマを発生させるプラズマ生成手段１を備え、前記ウエハステージ２７に載置した半導体ウエハ５にプラズマ処理を施すプラズマ処理装置２３において、該処理装置２３は、処理装置の状態量を電気的あるいは光学的に測定するセンサ９を備え、該センサ出力の微分値１７をもとにプラズマ放電の異常を検出する。

図１



【特許請求の範囲】

【請求項１】　処理ガス導入手段、排気手段及び半導体ウエハを載置するウエハステージを備えた真空チャンバと、
該真空チャンバ内に高周波電力を供給して前記真空チャンバ内にプラズマを発生させるプラズマ生成手段を備え、
前記ウエハステージに載置した半導体ウエハにプラズマ処理を施すプラズマ処理装置において、
該処理装置は、処理装置の状態量を電気的あるいは光学的に測定するセンサを備え、該センサ出力の微分値をもとにプラズマ放電の異常を検出することを特徴とするプラズマ処理装置。

【請求項２】　処理ガス導入手段、排気手段及び半導体ウエハを載置するウエハステージを備えた真空チャンバと、
該真空チャンバ内に高周波電力を供給して前記真空チャンバ内にプラズマを発生させるプラズマ生成手段を備え、
前記ウエハステージに載置した半導体ウエハにプラズマ処理を施すプラズマ処理装置において、
真空チャンバ内に供給する高周波電力の反射電力を測定するセンサを備え、該センサ出力の微分値をもとにプラズマ放電の異常を検出することを特徴とするプラズマ処理装置。

【請求項３】　請求項１ないし請求項２の何れか１の記載において、
プラズマ放電の異常は、センサ出力の所定時間内における最大値が予め設定した正の設定値よりも大きく、且つ前記所定時間内における最小値が予め設定した負の設定値よりも小さいときに異常と判定することを特徴とするプラズマ処理装置。

【請求項４】　処理ガス導入手段、排気手段及び半導体ウエハを載置するウエハステージを備えた真空チャンバと、
該真空チャンバ内にインピーダンス整合手段を介して高周波電力を供給して前記真空チャンバ内にプラズマを発生させるプラズマ生成手段を備え、
前記ウエハステージに載置した半導体ウエハにプラズマ処理を施すプラズマ処理装置において、
真空チャンバ内に供給する高周波電力の反射電力を測定するセンサの検出信号と、前記インピーダンス整合手段の変動を示す信号をもとにプラズマ放電の異常を検出することを特徴とするプラズマ処理装置。

【請求項５】　処理ガス導入手段、排気手段及び半導体ウエハを載置するウエハステージを備えた真空チャンバと、
該真空チャンバ内にインピーダンス整合手段を介して高周波電力を供給して前記真空チャンバ内にプラズマを発生させるプラズマ生成手段を備え、
前記ウエハステージに載置した半導体ウエハにプラズマ処理を施すプラズマ処理装置において、
真空チャンバ内に供給する高周波電力の反射電力を測定するセンサの検出信号と、前記インピーダンス整合手段を構成する素子の容量変動を示す信号をもとに、
高周波電力の反射波の時間的な変動が大きく、かつ前記整合手段の容量変動を示す信号の時間的な変動が小さい場合にプラズマ放電の異常と判定することを特徴とするプラズマ処理装置。

【請求項６】　処理ガス導入手段、排気手段及び半導体ウエハを載置するウエハステージを備えた真空チャンバと、
前記ウエハステージに高周波バイアス電圧を供給するバイアス用電源と、
該真空チャンバ内にインピーダンス整合手段を介して高周波電力を供給して前記真空チャンバ内にプラズマを発生させるプラズマ生成手段と、
前記真空チャンバ内のプラズマ発光を検出する光検出器とを備え、
前記ウエハステージに載置した半導体ウエハにプラズマ処理を施すプラズマ処理装置において、
前記バイアス用電源に係る信号及び前記光検出器の検出信号をもとにプラズマ放電の異常を検出することを特徴とするプラズマ処理装置。

【請求項７】　請求項１ないし請求項６の何れか１の記載において、プラズマ放電の異常を検出する異常放電検出手段は検出信号を収集するデータ収集手段を備え、収集手段に収集した正常放電時の収集データと比較することにより異常放電の発生を予測することを特徴とするプラズマ処理装置。

【請求項８】　処理ガス導入手段、排気手段及び半導体ウエハを載置するウエハステージを備えた真空チャンバと、
該真空チャンバ内に高周波電力を供給して前記真空チャンバ内にプラズマを発生させるプラズマ生成手段を備え、
前記ウエハステージに載置した半導体ウエハにプラズマ処理を施すプラズマ処理方法において、
真空チャンバ内に供給する高周波電力の反射電力を測定するセンサを備え、該センサ出力の微分値をもとにプラズマ放電の異常を検出し、該検出信号に基づき、警報の発報、処理中のプラズマ処理の停止、あるいは次以降の被処理物のプラズマ処理の停止の何れかを選択処理することを特徴とするプラズマ処理方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明はプラズマ処理装置及び処理方法に係り、特にプラズマ放電の異常（不安定放電を含む）に基づくプラズマ処理不良の発生を防止することのできるプラズマ処理装置等に関する。

【０００２】

【従来の技術】ＣＶＤ（化学的蒸着法）あるいはエッチング等のプラズマ処理装置においては、近年の半導体デバイスの微細化に対応して、ウエハ内に均一な処理結果が得られるプロセス条件の許容幅（プロセスウインドウ）が年々狭くなってきている。このためプラズマ処理装置は、より完全なプロセス条件での運用が望まれる。また、前記プロセス条件は、１枚のみでなく多数のウエハの処理期間に渡って安定していることが要求される。

【０００３】一般に、プロセス条件は、処理を重ねるにしたがって発生した反応生成物の付着等によって変動する。ＣＶＤ（化学的蒸着法）あるいはエッチングにおいては、処理を重ねるにしたがって発生した反応生成物の付着等によってチャンバの状態が変化し、徐々にプラズマ処理の条件がが変化する。例えば、チャンバに付着した反応生成物によってパーティクルが発生し、また、プラズマ処理中に解離種の組成、プラズマの電位あるいは密度等が変化する。

【０００４】以下、パーティクルの発生について具体的に述べる。通常、プラズマ処理を行う真空チャンバには、表面をアルマイト処理したアルミニウム等が用いられる。プラズマ処理を重ねて行くと前記アルマイト層上に反応生成物の堆積膜が生成される。この堆積膜の表面は、プラズマ中の電子によってチャージアップされやすくなっており、堆積膜表面の電子が過大な量となる。この電子がバルクプラズマ中に放出されることにより堆積膜が剥がれると、これらはダストとなってプラズマ中に放出される。このようなダストの一部はウエハ上に飛来し、プラズマ処理不良をもたらす。また、プラズマ中に異常放電が発生すると、ウエハ上の半導体素子がチャージアップし、過大な電流が流れることによって素子が破壊されることもある。更に、前記反応生成物の堆積膜によって、プラズマとチャンバの間の電気抵抗あるいは静電容量が変化したり、チャンバ表面における反応バランスが変わってプラズマ中の解離種の組成が変化することがある。この場合は、プラズマ放電自体が変化してプラズマの不安定を生じ、また、プラズマ処理の不良を引き起こす。

【０００５】

【発明が解決しようとする課題】前述のような異常放電やプラズマ不安定に起因するトラブルを未然に防ぐためには、堆積膜がある厚さ以上になる前に真空チャンバの洗浄等のメンテナンスを行うのが一般的である。しかしながら、メンテナンスを行うタイミングを正確に把握することは困難である。仮に、早めにメンテナンスを行うようにしても、プラズマ処理の履歴によっては、前記早めのメンテナンス周期内に異常放電や放電不安定による処理不良が発生する可能性は避けられない。

【０００６】本発明は、これらの問題点に鑑みてなされたもので、異常放電発生時にプラズマ処理を停止してプラズマ処理不良の発生を防止することのできるプラズマ処理装置を提供する。

【０００７】

【課題を解決するための手段】本発明は、上記の課題を解決するために次のような手段を採用した。

【０００８】処理ガス導入手段、排気手段及び半導体ウエハを載置するウエハステージを備えた真空チャンバと、該真空チャンバ２内に高周波電力を供給して前記真空チャンバ内にプラズマを発生させるプラズマ生成手段を備え、前記ウエハステージに載置した半導体ウエハ５にプラズマ処理を施すプラズマ処理装置において、該処理装置は、処理装置の状態量を電気的あるいは光学的に測定するセンサを備え、該センサ出力の微分値をもとにプラズマ放電の異常を検出する。

【０００９】

【発明の実施の形態】図１は、本発明の実施形態を示す図である。プラズマ処理装置２３におけるプラズマ処理部は、高周波電力発生手段（マイクロ波発生手段を含む）からの電力供給を受けてプラズマを生成するプラズマ生成手段１（例えば、高周波電圧が供給される電極等）、真空チャンバ２、真空チャンバにガスを導入する手段３、排気手段６などから構成される。また、真空チャンバの前記プラズマが生成される部分にはウエハステージ２７を備え、該ウエハステージ上には、図示しない搬送システムによって搬入したウエハを載置する。また、プラズマ生成手段１には、インピーダンス整合手段７を介して、高周波電力発生手段８が電気的に接続されている。

【００１０】高周波電力発生手段８と整合手段７との間には、伝達される高周波の進行波電力及び反射波電力を検出するための方向性結合器９が設置されている。方向性結合器からは、高周波電力発生手段が発生する周波数の進行波電力及び反射波電力に比例した電圧波形が出力される。進行波電力及び反射波電力に比例した電圧波形は、それぞれ検波回路１０及び１１によって検波される。次いで、これらの検波出力は、それぞれ増幅回路１２及び１３によって適正な電圧に増幅された後、進行は電力に比例した電圧信号１４及び反射は電力に比例した電圧信号１５となって出力される。

【００１１】ここで図２は方向性結合器から出力される反射波電力の波形５０を示す図、図３は反射波電力の検波後の波形５５を示す図である。

【００１２】前記方向性結合器９、検波回路１０及び１１及び増幅回路１２及び１３は、通常、高周波電力発生手段８を含む電源システム２２に内蔵されており、アナログ出力として、前記信号１４、１５が出力されていることが多い。

【００１３】図４は、プラズマに異常放電が発生した場合における検波後の波形６０を示す図である。図に示すように、種々のノイズを含んでいる。そこで第１のロー

パスフィルタ１６によって、高周波成分やノイズを取り除くことによって、図5に示すような信号６５が得られる。

【００１４】次に、信号６５を微分回路１７に供給して一次微分を行う。一次微分を得るには、様々な方法があるが、S.J Orfanidis： “Introduction to Signal Processing”： Prentice Hall (1996)に記載されているSavitzky-Golay平滑化微分法を用いることにより、図6に示すような、ノイズの影響の比較的少ない一次微分値信号７０を得ることができる。

【００１５】一次微分信号７０には若干のノイズ変動を含んでいるので、第2のローパスフィルタ１８をかけることにより、図7に示すような、最終的に異常放電の判別に用いる信号７５が得られる。

【００１６】異常放電を検出する異常放電検出回路１９には、反射波電力を示す信号１５をローパスフィルタ１６，１８及び微分回路によって処理した信号と、進行波電力を示す信号１４及びインピーダンス整合手段の変動を示す信号２０が入力される。

【００１７】インピーダンス整合手段7は、処理する周波数によってその形態が異なるが、高周波帯ないしＵＨＦ帯の整合器においては、内部に２つないし３つの可変コンデンサを有しており、これらの可変コンデンサの容量を変化させることによりインピーダンス整合をとる。したがって、前記インピーダンス整合手段の変動を示す信号２０は高周波帯ないしＵＨＦ帯の整合器においては、前記可変コンデンサの容量を示す信号とすることができる。

【００１８】なお、前記電源システム２２を含むプラズマ処理装置２３の全体は、制御システム４によって制御され、ウエハステージ２７上に載置されるウエハに対して順次プラズマ処理が施される。

【００１９】図8は、異常放電検出回路１９の動作を示すフローチャートである。まず、検出回路は、進行波電力信号Pf（信号１４）を常時モニタしており、信号１４が予め設定した値Pf0より大きい場合、プラズマ処理が開始されたものとして、動作を開始する（ステップ１）。検出回路は一定時間ごと（この場合は5秒毎）に、整合器に内蔵された3個の可変コンデンサの容量の変動の最大値ΔCmax、進行波電力信号Pfの変動ΔPfをチェックし（ステップ2）、これらの変動が、予め設定した値ΔC0、ΔPf0より大きい場合、プラズマの着火直後や処理ステップの切り替えなどの際中であるとして、異常放電の検出処理を行わない（ステップ４）。そうでない場合、プラズマがある程度安定した（異常放電や不安定が無いという意味ではない）状態であると判断し、異常放電の検出を開始する（ステップ５）。まず5秒間の反射波信号を図4ないし図7で説明したように、ローパスフィルタ１６、Savitzky-Golay平滑化微分回路１７、第2のローパスフィルタ１８によって処理し（ステップ５、６，７，８）、図7に示したような信号７５（最終的に異常放電の検出に用いる信号）を得る。

【００２０】次いで、前記5秒間における信号７５の最大値α（正）、最小値β（負）を判断の基準とし、最大値α、最小値βが、予め設定した値α0、及びβ0に対して、α＞α0、かつβ＜β0を満たしたとき、反射波の変動が異常に大きいとみなして、異常放電であると判断する（ステップ９、１０）。ここで、α＞α0、かつβ＜β0であることを異常放電の有無の判断に使用するのは、反射波が“増えて減る”、あるいは“減って増える”のが異常放電に特有な反射波の変動パターンであるからである。例えば、前記5秒間中にただ大きく減少した場合は、β＜β0を満たすが、α＞α0を満たさないため、安定放電と判断できる（ステップ１１）。

【００２１】図8に示したフローチャートにおいては、5秒間といった一定時間毎に異常放電の有無を判断したが、図7に示すように、まず最初の5秒間の処理を行った後、次に来る5秒間の処理を行っても良いし、あるいは、図9に示すように、ある時刻から5秒間さかのぼった時刻までの信号の履歴を用いて連続的に異常放電の有無を判断する処理を行っても良い。

【００２２】異常放電検出回路１９によって異常放電が発生したと判断した場合、異常放電検出信号２１を制御システム４に出力する。制御システム４は、直ちにプラズマ処理を停止することができる。なお、発生した異常放電の程度によってはプラズマ処理に対して重大な影響を与えない場合もあるため、処理中のウエハはそのままプラズマ処理を実行し、次以降のウエハのプラズマ処理を中断してもよい。あるいは警報を発報してもよい。

【００２３】以上の説明においては、プラズマの異常放電を検出するための信号としてプラズマ生成用高周波電力の反射波を用いていたが、本発明は反射波に限定されることなく、プラズマ処理状態を示す電気的あるいは光学的な信号の全てが利用可能である。

【００２４】また、プラズマの異常放電を検出するための信号としては、プラズマ生成用高周波電力の反射波の外に他の手段からの検出信号を組み合わせて利用することができる。

【００２５】例えば、インピーダンス整合手段７の変動を示す信号２０（可変コンデンサの容量を示す信号）等を利用することができる。この場合は検出した高周波電力の反射波の時間的な変動の程度が大きく、かつ前記整合手段の変動を示す信号２０の時間的な変動の程度が小さい場合に異常放電が発生したと判別することができる。

【００２６】図１０は、他の実施形態を示す図である。なお、図において図１に示される部分と同一部分については同一符号を付してその説明を省略する。プラズマ処理装置においては、被処理物に入射するイオンエネルギーを制御するために、プラズマ生成用電源とは別の高周

波電源31（以下、バイアス用電源と呼ぶ）が、バイアス用整合器30を介して被処理物を載置するウエハステージ27に接続される。図10では、プラズマ生成用の高周波電力の反射波に替えて、このバイアス用電源31のピーク電圧32、DC成分33、反射電力34等のバイアス用電源に係る信号を第1のローパスフィルタ16に供給する。ローパスフィルタ16，微分回路17及び第2のローパスフィルタ18はこれらの信号をフィルタ及び微分処理を行った後、異常放電検出回路19に供給する。異常放電検出回路はこれらの信号、あるいはこれらの信号と前記インピーダンス整合手段7の変動を示す信号20（可変コンデンサの容量を示す信号）等を利用することにより、プラズマ生成用電力の反射波を検出する場合と同様にプラズマの不安定や異常放電を検出することが可能である。

【0027】また、真空チャンバに設けた光検出器28によって得られたプラズマ発光を検出し、検出したプラズマ発光を分光及び信号増幅ユニット29を介して分光し、この分光信号を第1のローパスフィルタ16，微分回路17及び第2のローパスフィルタ18を介して異常信号検出回路に供給するようにしても上記と同様にプラズマの異常放電を検出することが可能である。

【0028】図11は、さらに他の実施形態を示す図である。なお、図において図1に示される部分と同一部分については同一符号を付してその説明を省略する。

【0029】図において、データ収集部25は制御システム4からプロセスレシピデータ信号26を受信することにより、真空チャンバに供給するガス流量、電力、ガス圧力等、プラズマ処理に必要なプロセスレシピデータを常時収集する。また、進行波電力、反射波電力、インピーダンス整合手段の変動を示す信号も同様に収集する。

【0030】異常放電検出回路19は、これら全てのデータを常時監視する。全く同じプロセスレシピにおいて、既に処理したウエハに対するこれらの処理信号の履歴信号に対して、新たに行ったプラズマ処理信号が大きく異なる場合はこれを検出し、制御システム4に異常信号を送り、ユーザに警告を発する。あるいは、処理実行中のウエハのプラズマ処理もしくは処理実行中のウエハの次以降のウエハのプラズマ処理を停止する。

【0031】図1に示す例においては、予め異常放電を判断するための適切なパラメータ（$\alpha 0$、$\beta 0$）を設定しておく必要があるが、この例においては、プロセスレシピデータと、たとえは反射波電力の変動を示す信号データとを蓄積し、正常な処理をおこなったときの履歴データと現在行っている処理信号とを比較をすることにより、異常放電発生の検出あるいは予測を行うことができる。

【0032】以上説明したように、真空チャンバへの反応生成物の堆積に伴う異常放電を速やかに検知することができる。また、この検知に基づき、例えばプラズマ処理を中断し、パーティクル、チャージアップダメージ、プロセスのシフト等に起因するプラズマ処理不良を防止することができる。従って、全体としてのプラズマ処理性能、および装置の稼働率が向上し、微細なエッチング加工や、高品質な成膜加工、表面処理加工等が可能となる。

【0033】

【発明の効果】以上説明したように本発明によれば、異常放電発生時にプラズマ処理を停止してプラズマ処理不良の発生を防止することのできるプラズマ処理装置を提供することができる。

【図面の簡単な説明】

【図1】本発明の実施形態にかかるプラズマ処理装置を示す図である。

【図2】方向性結合器から出力される反射電力の波形を示す図である。

【図3】反射電力の検波後の波形を示す図である。

【図4】プラズマに異常放電が発生した場合の検波後の波形を示す図である。

【図5】ローパスフィルタによる処理後の波形を示す図である。

【図6】一次微分信号を示す図である。

【図7】異常放電の判別に用いる信号の波形を示す図である。

【図8】異常放電検出回路の動作を示すフローチャートである。

【図9】履歴を用いて行う異常放電の判別を説明する図である。

【図10】他の実施形態を説明する図である。

【図11】さらに他の実施形態を説明する図である。

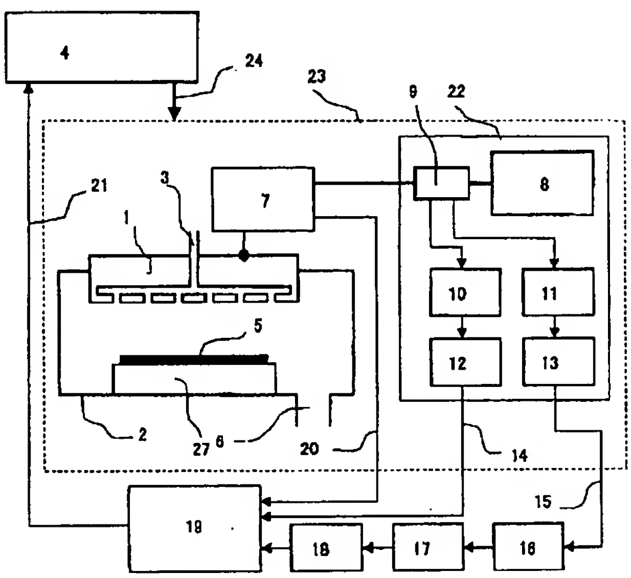
【符号の説明】

1　プラズマ生成手段
2　真空チャンバ
3　ガス導入手段
4　プラズマ処理装置の制御システム
5　半導体ウエハ
6　排気手段
7　インピーダンス整合器
8　高周波電力発生手段
9　方向性結合器
10，11　検波回路
12，13　増幅回路
16　第1のローパスフィルタ
17　一次微分回路
18　第2のローパスフィルタ
19　異常放電検出回路
22　電源システム
23　プラズマ処理装置
25　データ収集部

27　ウエハステージ
28　光検出器
29　分光及び信号増幅ユニット
30　バイアス用整合器
31　バイアス用高周波電源

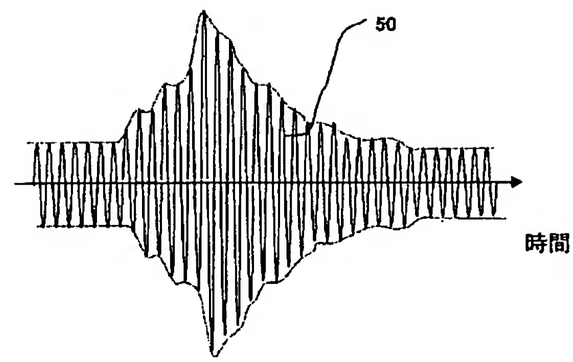
【図1】

図1



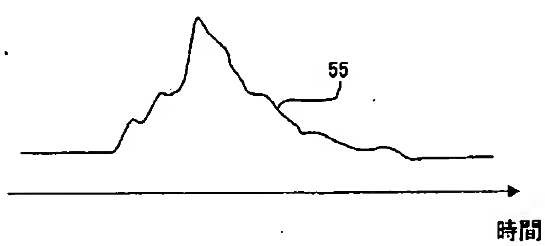
【図2】

図2



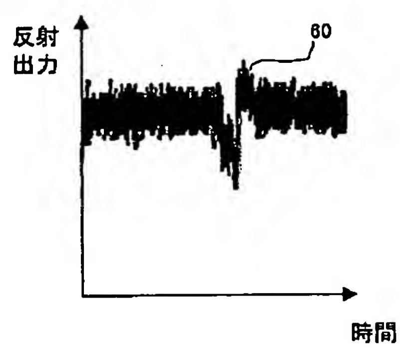
【図3】

図3



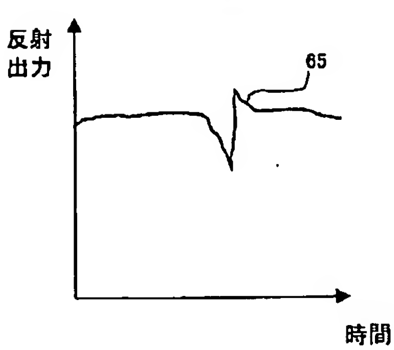
【図4】

図4



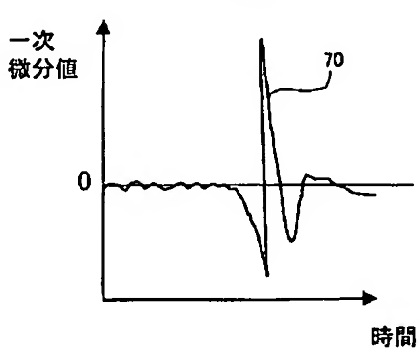
【図5】

図5



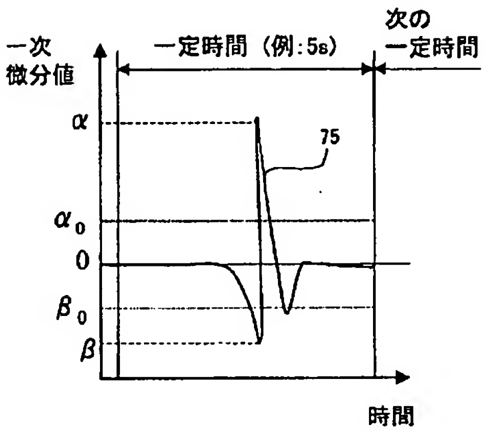
【図6】

図6



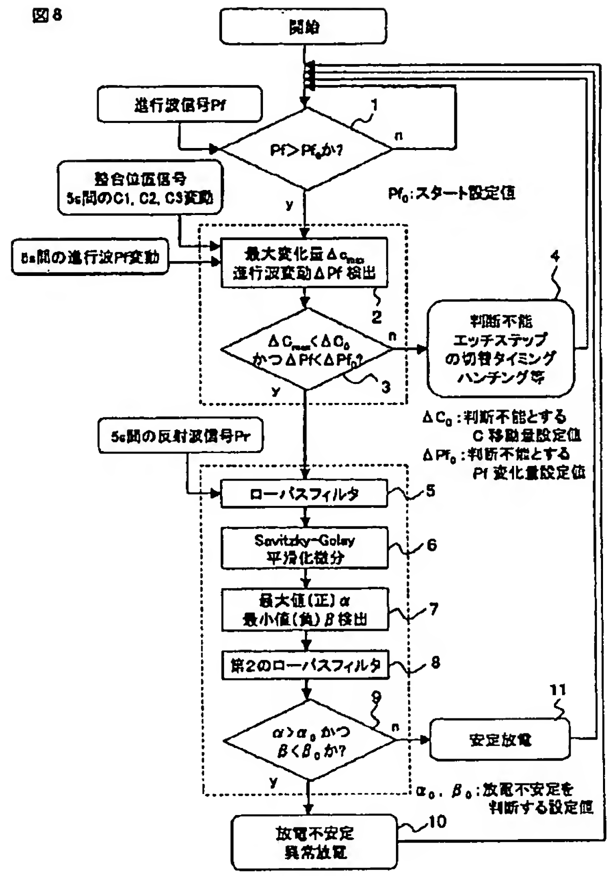
【図７】

図７



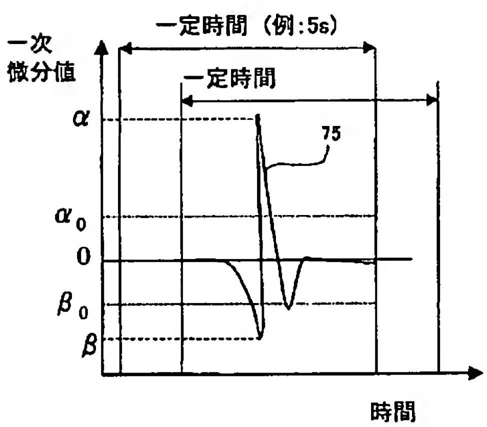
【図８】

図８



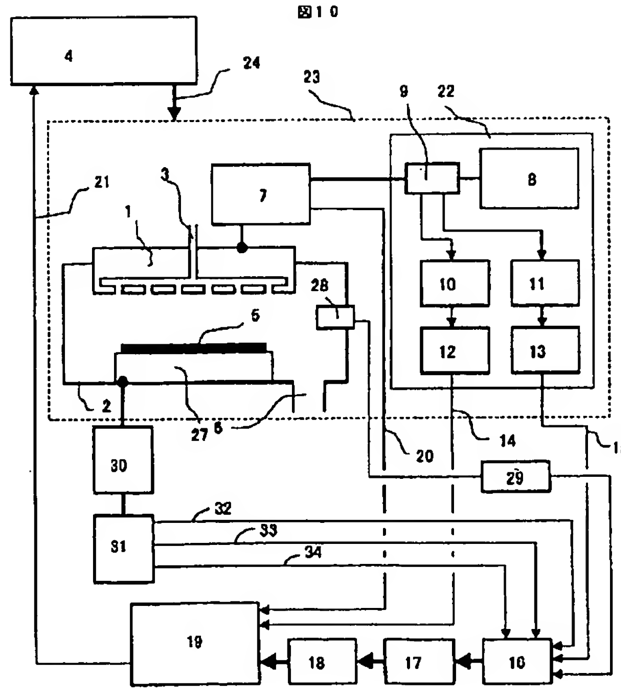
【図９】

図９

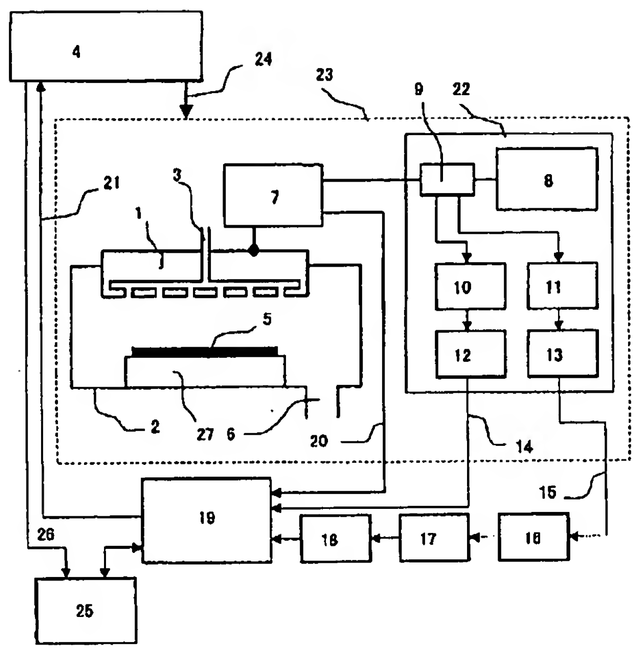


【図１０】

図１０



【図１１】



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(72)発明者 牧野 昭孝
山口県下松市大字東豊井794番地 株式会社日立ハイテクノロジーズ設計・製造統括本部笠戸事業所内

(72)発明者 山本 秀之
山口県下松市大字東豊井794番地 株式会社日立ハイテクノロジーズ設計・製造統括本部笠戸事業所内

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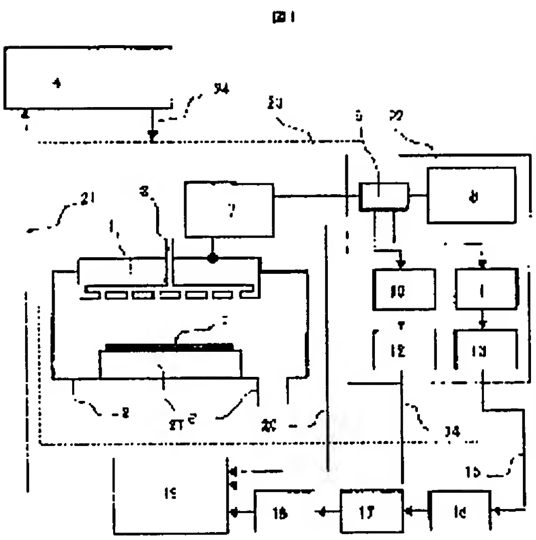
(71)Applicant : HITACHI HIGH-TECHNOLOGIES CORP

(72)Inventor : EDAMURA MANABU
IKENAGA KAZUYUKI
MAKINO AKITAKA
YAMAMOTO HIDEYUKI

(54) APPARATUS AND METHOD FOR PLASMA TREATING



(57)Abstract:
PROBLEM TO BE SOLVED: To prevent a plasma treating fault from occurring by stopping the plasma process when an abnormal discharge occurs.
SOLUTION: The apparatus 23 for plasma treating a semiconductor wafer 5 which places a wafer stage 27 comprises a treating gas introducing means 3, a vacuum chamber 2 having the wafer stage 27 for placing an exhaust means 6 and a semiconductor wafer, and a plasma generating means 1 for generating a plasma in the chamber 2 by supplying a high-frequency power into the chamber 2. The apparatus 23 further comprises a sensor 9 for electrically or optically measuring the state amount of the apparatus to detect the abnormal plasma discharge based on the differentiated value 17 of the output of the sensor.

CLAIMS

[Claim(s)]

[Claim 1] The vacuum chamber equipped with the wafer stage in which a raw gas installation means, an exhaust air means, and a semi-conductor wafer are laid, In the plasma treatment equipment which performs plasma treatment to the semi-conductor wafer which was equipped with a plasma production means to supply high-frequency power in this vacuum chamber, and to generate the plasma in said vacuum chamber, and was laid in said wafer stage This processor is plasma treatment equipment characterized by having the sensor which measures the quantity of state of a processor electrically or optically, and detecting the abnormalities of plasma discharge based on

the differential value of this sensor output.

[Claim 2] The vacuum chamber equipped with the wafer stage in which a raw gas installation means, an exhaust air means, and a semi-conductor wafer are laid, In the plasma treatment equipment which performs plasma treatment to the semi-conductor wafer which was equipped with a plasma production means to supply high-frequency power in this vacuum chamber, and to generate the plasma in said vacuum chamber, and was laid in said wafer stage Plasma treatment equipment characterized by having the sensor which measures the reflective power of the high-frequency power supplied in a vacuum chamber, and detecting the abnormalities of plasma discharge based on the differential value of this sensor output.

[Claim 3] It is plasma treatment equipment characterized by setting to the publication of any one of claim 1 thru/or claim 2, and judging with the abnormalities of plasma discharge being unusual when it is larger than the forward set point which the maximum within the predetermined time of a sensor output set up beforehand and the minimum value within said predetermined time is smaller than the negative set point set up beforehand.

[Claim 4] The vacuum chamber equipped with the wafer stage in which a raw gas installation means, an exhaust air means, and a semi-conductor wafer are laid, It has a plasma production means to supply high-frequency power through an impedance matching means in this vacuum chamber, and to generate the plasma in said vacuum

chamber. In the plasma treatment equipment which performs plasma treatment to the semi-conductor wafer laid in said wafer stage Plasma treatment equipment characterized by detecting the abnormalities of plasma discharge based on the detecting signal of the sensor which measures the reflective power of the high-frequency power supplied in a vacuum chamber, and the signal which shows fluctuation of said impedance matching means.

[Claim 5] The vacuum chamber equipped with the wafer stage in which a raw gas installation means, an exhaust air means, and a semi-conductor wafer are laid, It has a plasma production means to supply high-frequency power through an impedance matching means in this vacuum chamber, and to generate the plasma in said vacuum chamber. In the plasma treatment equipment which performs plasma treatment to the semi-conductor wafer laid in said wafer stage The detecting signal of the sensor which measures the reflective power of the high-frequency power supplied in a vacuum chamber, Plasma treatment equipment characterized by judging with time fluctuation of the reflected wave of high-frequency power being large, and plasma discharge being unusual when time fluctuation of the signal which shows capacity fluctuation of said adjustment means is small based on the signal which shows capacity fluctuation of the component which constitutes said impedance matching means.

[Claim 6] The vacuum chamber equipped with the wafer stage in which a raw gas installation means, an exhaust air means, and a semi-conductor wafer are laid, The power source for bias which supplies high frequency bias voltage to said wafer stage, A

plasma production means to supply high-frequency power through an impedance matching means in this vacuum chamber, and to generate the plasma in said vacuum chamber, In the plasma treatment equipment which performs plasma treatment to the semi-conductor wafer which was equipped with the photodetector which detects plasma luminescence in said vacuum chamber, and was laid in said wafer stage Plasma treatment equipment characterized by detecting the abnormalities of plasma discharge based on the signal concerning said power source for bias, and the detecting signal of said photodetector.

[Claim 7] An abnormality discharge detection means to detect the abnormalities of plasma discharge in the publication of any one of claim 1 thru/or claim 6 is plasma treatment equipment characterized by predicting generating of abnormality discharge by comparing with the collection data at the time of the normal discharge which was equipped with a data collection means to collect detecting signals, and was collected for the collection means.

[Claim 8] The vacuum chamber equipped with the wafer stage in which a raw gas installation means, an exhaust air means, and a semi-conductor wafer are laid, In the plasma treatment approach of performing plasma treatment to the semi-conductor wafer which was equipped with a plasma production means to supply high-frequency power in this vacuum chamber, and to generate the plasma in said vacuum chamber, and was laid in said wafer stage It has the sensor which measures the reflective power of the high-frequency power supplied in a vacuum chamber. The plasma treatment approach characterized by detecting the abnormalities of plasma discharge based on the

differential value of this sensor output, and carrying out selection processing of any of the alert of an alarm, a halt of the plasma treatment under processing, or a halt of the plasma treatment of the processed material after a degree they are based on this detecting signal.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the plasma treatment equipment which can be applied to plasma treatment equipment and an art, especially can prevent generating of the poor plasma treatment based on the abnormalities (unstable discharge is included) of plasma discharge.

[0002]

[Description of the Prior Art] In plasma treatment equipments, such as CVD (chemical vapor deposition) or etching, the permission width of face (process window) of the process conditions from which a uniform processing result is obtained in a wafer is becoming narrow every year corresponding to detailed-izing of a semiconductor device in recent years. For this reason, employment on process conditions with more perfect plasma treatment equipment is desired. Moreover, it is required that said process conditions should be stable over the processing period of the wafer of not only one sheet but a large number.

[0003] Generally, process conditions are changed by adhesion of the resultant generated as processing was repeated etc. In CVD (chemical vapor deposition) or etching, by adhesion of the resultant generated as processing was repeated etc., the condition of a chamber changes and the conditions of plasma treatment ****** gradually. For example, particle occurs with the resultant adhering to a chamber, and potential or a consistency of the presentation of a dissociation kind and the plasma etc. changes during plasma treatment.

[0004] Hereafter, generating of particle is described concretely. Usually, the aluminum which carried out alumite processing of the front face is used for the vacuum chamber which performs plasma treatment. If it goes plasma treatment in piles, the deposition film of a resultant will be generated on said alumite layer. The front face of this deposition film has become with the electron in the plasma that the charge up is easy to be carried out, and the electron of a deposition film front face serves as an excessive amount. If the deposition film separates by emitting this electron into the bulk plasma, these will serve as dust and will be emitted into the plasma. A part of such dust comes flying on a wafer, and it brings about poor plasma treatment. Moreover, when abnormality discharge occurs in the plasma, the semiconductor device on a wafer carries out the charge up, and a component may be destroyed when an excessive current flows. Furthermore, the electric resistance or electrostatic capacity between the plasma and a chamber may change, or the reaction balance in a chamber front face may change, and the presentation of the dissociation kind in the plasma may change with the deposition film of said resultant. In this case, the plasma discharge itself changes, and the instability of the plasma is produced, and the defect of plasma

treatment is caused.

[0005]

[Problem(s) to be Solved by the Invention] In order to prevent the trouble resulting from the above abnormality discharge or plasma instability, before becoming more than thickness with the deposition film, it is common to maintain washing of a vacuum chamber etc. However, it is difficult to grasp the timing which maintains correctly. Even if it is made to maintain a little early, possibility that the poor processing by abnormality discharge or discharge instability will occur in said early maintenance period depending on the hysteresis of plasma treatment will not be avoided.

[0006] This invention was made in view of these troubles, and offers the plasma treatment equipment which can suspend plasma treatment and can prevent generating of poor plasma treatment at the time of abnormality discharge generating.

[0007]

[Means for Solving the Problem] The following means were used for this invention in order to solve the above-mentioned technical problem.

[0008] The vacuum chamber equipped with the wafer stage in which a raw gas installation means, an exhaust air means, and a semi-conductor wafer are laid, In the plasma treatment equipment which performs plasma treatment to the semi-conductor wafer 5 which was equipped with a plasma production means to supply high-frequency power in this vacuum chamber 2, and to generate the plasma in said vacuum chamber, and was laid in said wafer stage This processor is equipped with the sensor which measures the quantity of state of a processor electrically or optically, and detects the abnormalities of plasma discharge based on the differential value of this sensor output.

[0009]

[Embodiment of the Invention] Drawing 1 is drawing showing the operation gestalt of this invention. The plasma treatment section in plasma treatment equipment 23 consists of the means 3, the exhaust air means 6, etc. of introducing gas into plasma production means 1 (for example, electrode with which high-frequency voltage is supplied) to generate the plasma in response to the electric power supply from a high-frequency power generating means (for a microwave generating means to be included), the vacuum chamber 2, and a vacuum chamber. Moreover, the part by which said plasma of a vacuum chamber is generated is equipped with the wafer stage 27, and the wafer carried in with the carrier system which is not illustrated is laid on this wafer stage. Moreover, the high-frequency power generating means 8 is electrically connected to the plasma production means 1 through the impedance matching means 7.

[0010] Between the high-frequency power generating means 8 and the adjustment means 7, the directional coupler 9 for detecting the progressive wave power and reflected wave power of a RF which are transmitted is installed. From a directional coupler, the voltage waveform proportional to the progressive wave power and reflected wave power of a frequency which a high-frequency power generating means generates is outputted. The voltage waveform proportional to progressive wave power and reflected wave power is detected by detector circuits 10 and 11, respectively. Subsequently, after these detection outputs are amplified by amplifying circuits 12 and 13 at a proper electrical potential difference, respectively, the voltage signal 14 with which advance is proportional to power, and reflection serve as the voltage signal 15 proportional to power, and are outputted.

[0011] the wave of the reflected wave power with which drawing 2 is outputted from a directional coupler here -- drawing and drawing 3 which show 50 -- the wave after detection of reflected wave power -- it is drawing showing 55.

[0012] Said directional coupler 9, detector circuits 10 and 11, and amplifying circuits 12 and 13 are usually built in the power-source system 22 including the high-frequency power generating means 8, and said signals 14 and 15 are outputted as analog output in many cases.

[0013] the wave after detection when drawing 4 generates abnormality discharge to the plasma -- it is drawing showing 60. Various noises are included as shown in drawing. Then, with the 1st low pass filter 16, the signal 65 as shown in drawing 5 is acquired by removing a high frequency component and a noise.

[0014] Next, a signal 65 is supplied to a differential circuit 17, and primary differential is performed. It is S.J Orfanidis, although there are various approaches in order to obtain primary differential. : "Introduction to Signal Processing": By using the Savitzky-Golay smoothing differentiation indicated by Prentice Hall (1996), comparatively few primary differential value signals 70 of the effect of a noise as shown in drawing 6 can be acquired.

[0015] Since some noise fluctuation is included in the primary differential signal 70, the signal 75 finally used for distinction of abnormality discharge as shown in drawing 7 is acquired by covering the 2nd low pass filter 18.

[0016] The signal which processed the signal 15 which shows reflected wave power by low pass filters 16 and 18 and the differential circuit, and the signal 20 which shows fluctuation of the signal 14 and impedance matching means which show progressive

wave power are inputted into the abnormality discharge detector 19 which detects abnormality discharge.

[0017] Although the gestalt changes with frequencies to process, in the adjustment machine of a high frequency band thru/or a UHF band, the impedance matching means 7 has two thru/or three variable capacitors inside, and takes impedance matching by changing the capacity of these variable capacitors. Therefore, the signal 20 which shows fluctuation of said impedance matching means can be made into the signal which shows the capacity of said variable capacitor in the adjustment machine of a high frequency band thru/or a UHF band.

[0018] In addition, the whole plasma treatment equipment 23 containing said power-source system 22 is controlled by the control system 4, and plasma treatment is performed one by one to the wafer laid on the wafer stage 27.

[0019] Drawing 8 is a flow chart which shows actuation of the abnormality discharge detector 19. First, the detector is always carrying out the monitor of the progressive wave power signal Pf (signal 14), and when a signal 14 is larger than the value Pf0 set up beforehand, actuation is started as that by which plasma treatment was started (step 1). Maximum deltaCmax of fluctuation of the capacity of three variable capacitors with which the detector was built in the adjustment machine for every (every [in this case,] 5 seconds) fixed time amount, Fluctuation deltaPf of the progressive wave power signal Pf is checked (step 2), and detection processing of abnormality discharge is not performed noting that it is inside in the cases, such as immediately after ignition of the plasma, and a change of a processing step, when these fluctuation is larger than the values delta C0 and delta Pf0 set up beforehand (step 4). When that is not right, the

plasma judges that it is in the condition (it is not the semantics that there is neither abnormality discharge nor instability) stabilized to some extent, and starts detection of abnormality discharge (step 5). As drawing 4 thru/or drawing 7 explained the reflected wave signal for 5 seconds first, it processes with a low pass filter 16, the Savitzky-Golay smoothing differential circuit 17, and the 2nd low pass filter 18 (steps 5, 6, 7, and 8), and the signal 75 (signal finally used for detection of abnormality discharge) as shown in drawing 7 is acquired.

[0020] Subsequently, it considers as the criteria of decision of Maximum alpha (forward) and the minimum value beta (negative) of the signal 75 for [said] 5 seconds, and when Maximum alpha and the minimum value beta fill alpha>alpha 0 and beta<beta 0 to the values alpha0 and beta0 set up beforehand, fluctuation of a reflected wave considers that it is unusually large, and judges that it is abnormality discharge (steps 9 and 10). Here, it uses that they are alpha>alpha 0 and beta<beta 0 for decision of the existence of abnormality discharge because a reflected wave is "it increasing and decreasing" or the fluctuation pattern of a reflected wave with that peculiar to abnormality discharge of "a decrease increases." For example, when it merely decreases greatly for said 5 seconds throughout, beta<beta 0 is filled, but since alpha>alpha 0 is not filled, it can be judged as stable discharge (step 11).

[0021] In the flow chart shown in drawing 8 , although the existence of abnormality discharge was judged for every [which is called for 5 seconds] fixed time amount As shown in drawing 7 , after performing the first processing for 5 seconds first, as processing for [it comes to a degree] 5 seconds may be performed or it is shown in drawing 9 , processing which judges the existence of abnormality discharge

continuously using the hysteresis of the signal by the time of day which went back for 5 seconds after a certain time of day may be performed.

[0022] When it is judged that abnormality discharge occurred by the abnormality discharge detector 19, the abnormality discharge detecting signal 21 is outputted to a control system 4. A control system 4 can suspend plasma treatment immediately. In addition, also when it does not have serious effect to plasma treatment depending on extent of the generated abnormality discharge, for a certain reason, the wafer under processing may perform plasma treatment as it is, and may interrupt the plasma treatment of the wafer after a degree. Or you may give the alert for an alarm.

[0023] In the above explanation, although the reflected wave of the high-frequency power for plasma production was used as a signal for detecting abnormality discharge of the plasma, all the electric or optical signals of this invention that show a plasma treatment condition are available, without being limited to a reflected wave.

[0024] Moreover, as a signal for detecting abnormality discharge of the plasma, it can use combining the detecting signal from other means out of the reflected wave of the high-frequency power for plasma production.

[0025] For example, the signal 20 (signal which shows the capacity of a variable capacitor) which shows fluctuation of the impedance matching means 7 can be used. In this case, when extent of time fluctuation of the reflected wave of the detected high-frequency power is large and extent of time fluctuation of the signal 20 which shows fluctuation of said adjustment means is small, it can distinguish that abnormality discharge occurred.

[0026] Drawing 10 is drawing showing other operation gestalten. In addition, the same

sign is attached about the same part as the part shown in drawing 1 in drawing, and the explanation is omitted. In plasma treatment equipment, in order to control the ion energy which carries out incidence to a processed material, RF generator 31 (it is hereafter called the power source for bias) other than the power source for plasma production is connected to the wafer stage 27 in which a processed material is laid through the adjustment machine 30 for bias. In drawing 10 , it changes to the reflected wave of the high-frequency power for plasma production, and the signal concerning the peak voltage 32 of this power source 31 for bias, the DC component 33, and the power source for bias of reflective power 34 grade is supplied to the 1st low pass filter 16. A low pass filter 16, a differential circuit 17, and the 2nd low pass filter 18 supply these signals to the abnormality discharge detector 19, after performing a filter and differential processing. An abnormality discharge detector can detect the instability of the plasma, and abnormality discharge like the case where the reflected wave of the power for plasma production is detected, by using these signals, these signals, the signal 20 (signal which shows the capacity of a variable capacitor) which shows fluctuation of said impedance matching means 7, etc.

[0027] Moreover, plasma luminescence obtained by the photodetector 28 formed in the vacuum chamber is detected, and even if it carries out the spectrum of the plasma luminescence which detected through a spectrum and the signal magnification unit 29 and supplies a lightwave signal to an abnormality signal detector through the 1st low pass filter 16, differential circuit 17, and 2nd low pass filter 18 at this rate, it is possible to detect abnormality discharge of the plasma like the above.

[0028] Drawing 11 is drawing showing the operation gestalt of further others. In addition,

the same sign is attached about the same part as the part shown in drawing 1 in drawing, and the explanation is omitted.

[0029] In drawing, as for the data collection section 25, the quantity of gas flow supplied to a vacuum chamber, power, gas pressure, etc. always collect process recipe data required for plasma treatment by receiving the process recipe data signal 26 from a control system 4. Moreover, the signals which show fluctuation of progressive wave power, reflected wave power, and an impedance matching means are collected similarly.

[0030] The abnormality discharge detector 19 monitors all these data continuously. In the completely same process recipe, when the newly performed plasma treatment signals differ greatly to the hysteresis signal of these processing signals over the already processed wafer, this is detected, an abnormality signal is emitted to a control system 4, and it emits warning to delivery and a user. Or the plasma treatment of the wafer under processing activation or the plasma treatment of the wafer after the degree of the wafer under processing activation is suspended.

[0031] Although it is necessary to set up the suitable parameter (alpha0, beta0) for judging abnormality discharge beforehand in the example shown in drawing 1 In this example, process recipe data and a metaphor can perform detection or prediction of abnormality discharge generating, when the signal data in which fluctuation of reflected wave power is shown are stored and the historical data and the current line when performing normal processing compare the processing signal which is.

[0032] As explained above, the abnormality discharge accompanying deposition of the resultant to a vacuum chamber is promptly detectable. Moreover, based on this

detection, plasma treatment can be interrupted and the poor plasma treatment resulting from the shift of particle, a charge-up damage, and a process etc. can be prevented. Therefore, the plasma treatment engine performance as the whole and the operating ratio of equipment improve, and detailed etching processing, quality membrane formation processing, surface treatment processing, etc. are attained.

[0033]

[Effect of the Invention] As explained above, according to this invention, the plasma treatment equipment which can suspend plasma treatment and can prevent generating of poor plasma treatment at the time of abnormality discharge generating can be offered.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention] This invention relates to the plasma treatment equipment which can be applied to plasma treatment equipment and an art, especially can prevent generating of the poor plasma treatment based on the abnormalities (unstable discharge is included) of plasma discharge.

PRIOR ART

[Description of the Prior Art] In plasma treatment equipments, such as CVD (chemical vapor deposition) or etching, the permission width of face (process window) of the

process conditions from which a uniform processing result is obtained in a wafer is becoming narrow every year corresponding to detailed-izing of a semiconductor device in recent years. For this reason, employment on process conditions with more perfect plasma treatment equipment is desired. Moreover, it is required that said process conditions should be stable over the processing period of the wafer of not only one sheet but a large number.

[0003] Generally, process conditions are changed by adhesion of the resultant generated as processing was repeated etc. In CVD (chemical vapor deposition) or etching, by adhesion of the resultant generated as processing was repeated etc., the condition of a chamber changes and the conditions of plasma treatment ****** gradually. For example, particle occurs with the resultant adhering to a chamber, and potential or a consistency of the presentation of a dissociation kind and the plasma etc. changes during plasma treatment.

[0004] Hereafter, generating of particle is described concretely. Usually, the aluminum which carried out alumite processing of the front face is used for the vacuum chamber which performs plasma treatment. If it goes plasma treatment in piles, the deposition film of a resultant will be generated on said alumite layer. The front face of this deposition film has become with the electron in the plasma that the charge up is easy to be carried out, and the electron of a deposition film front face serves as an excessive amount. If the deposition film separates by emitting this electron into the bulk plasma, these will serve as dust and will be emitted into the plasma. A part of such dust comes flying on a wafer, and it brings about poor plasma treatment. Moreover, when abnormality discharge occurs in the plasma, the semiconductor device on a wafer

carries out the charge up, and a component may be destroyed when an excessive current flows. Furthermore, the electric resistance or electrostatic capacity between the plasma and a chamber may change, or the reaction balance in a chamber front face may change, and the presentation of the dissociation kind in the plasma may change with the deposition film of said resultant. In this case, the plasma discharge itself changes, and the instability of the plasma is produced, and the defect of plasma treatment is caused.

EFFECT OF THE INVENTION

[Effect of the Invention] As explained above, according to this invention, the plasma treatment equipment which can suspend plasma treatment and can prevent generating of poor plasma treatment at the time of abnormality discharge generating can be offered.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] In order to prevent the trouble resulting from the above abnormality discharge or plasma instability, before becoming more than thickness with the deposition film, it is common to maintain washing of a vacuum chamber etc. However, it is difficult to grasp the timing which maintains correctly. Even if it is made to maintain a little early, possibility that the poor processing by abnormality discharge or discharge instability will occur in said early maintenance period depending

on the hysteresis of plasma treatment will not be avoided.

[0006] This invention was made in view of these troubles, and offers the plasma treatment equipment which can suspend plasma treatment and can prevent generating of poor plasma treatment at the time of abnormality discharge generating.

MEANS

[Means for Solving the Problem] The following means were used for this invention in order to solve the above-mentioned technical problem.

[0008] The vacuum chamber equipped with the wafer stage in which a raw gas installation means, an exhaust air means, and a semi-conductor wafer are laid, In the plasma treatment equipment which performs plasma treatment to the semi-conductor wafer 5 which was equipped with a plasma production means to supply high-frequency power in this vacuum chamber 2, and to generate the plasma in said vacuum chamber, and was laid in said wafer stage This processor is equipped with the sensor which measures the quantity of state of a processor electrically or optically, and detects the abnormalities of plasma discharge based on the differential value of this sensor output.

[0009]

[Embodiment of the Invention] Drawing 1 is drawing showing the operation gestalt of this invention. The plasma treatment section in plasma treatment equipment 23 consists of the means 3, the exhaust air means 6, etc. of introducing gas into plasma production means 1 (for example, electrode with which high-frequency voltage is supplied) to

generate the plasma in response to the electric power supply from a high-frequency power generating means (for a microwave generating means to be included), the vacuum chamber 2, and a vacuum chamber. Moreover, the part by which said plasma of a vacuum chamber is generated is equipped with the wafer stage 27, and the wafer carried in with the carrier system which is not illustrated is laid on this wafer stage. Moreover, the high-frequency power generating means 8 is electrically connected to the plasma production means 1 through the impedance matching means 7.

[0010] Between the high-frequency power generating means 8 and the adjustment means 7, the directional coupler 9 for detecting the progressive wave power and reflected wave power of a RF which are transmitted is installed. From a directional coupler, the voltage waveform proportional to the progressive wave power and reflected wave power of a frequency which a high-frequency power generating means generates is outputted. The voltage waveform proportional to progressive wave power and reflected wave power is detected by detector circuits 10 and 11, respectively. Subsequently, after these detection outputs are amplified by amplifying circuits 12 and 13 at a proper electrical potential difference, respectively, the voltage signal 14 with which advance is proportional to power, and reflection serve as the voltage signal 15 proportional to power, and are outputted.

[0011] the wave of the reflected wave power with which drawing 2 is outputted from a directional coupler here -- drawing and drawing 3 which show 50 -- the wave after detection of reflected wave power -- it is drawing showing 55.

[0012] Said directional coupler 9, detector circuits 10 and 11, and amplifying circuits 12 and 13 are usually built in the power-source system 22 including the high-frequency

power generating means 8, and said signals 14 and 15 are outputted as analog output in many cases.

[0013] the wave after detection when drawing 4 generates abnormality discharge to the plasma -- it is drawing showing 60. Various noises are included as shown in drawing. Then, with the 1st low pass filter 16, the signal 65 as shown in drawing 5 is acquired by removing a high frequency component and a noise.

[0014] Next, a signal 65 is supplied to a differential circuit 17, and primary differential is performed. It is S.J Orfanidis, although there are various approaches in order to obtain primary differential. : "Introduction to Signal Processing": By using the Savitzky-Golay smoothing differentiation indicated by Prentice Hall (1996), comparatively few primary differential value signals 70 of the effect of a noise as shown in drawing 6 can be acquired.

[0015] Since some noise fluctuation is included in the primary differential signal 70, the signal 75 finally used for distinction of abnormality discharge as shown in drawing 7 is acquired by covering the 2nd low pass filter 18.

[0016] The signal which processed the signal 15 which shows reflected wave power by low pass filters 16 and 18 and the differential circuit, and the signal 20 which shows fluctuation of the signal 14 and impedance matching means which show progressive wave power are inputted into the abnormality discharge detector 19 which detects abnormality discharge.

[0017] Although the gestalt changes with frequencies to process, in the adjustment machine of a high frequency band thru/or a UHF band, the impedance matching means 7 has two thru/or three variable capacitors inside, and takes impedance matching by

changing the capacity of these variable capacitors. Therefore, the signal 20 which shows fluctuation of said impedance matching means can be made into the signal which shows the capacity of said variable capacitor in the adjustment machine of a high frequency band thru/or a UHF band.

[0018] In addition, the whole plasma treatment equipment 23 containing said power-source system 22 is controlled by the control system 4, and plasma treatment is performed one by one to the wafer laid on the wafer stage 27.

[0019] Drawing 8 is a flow chart which shows actuation of the abnormality discharge detector 19. First, the detector is always carrying out the monitor of the progressive wave power signal Pf (signal 14), and when a signal 14 is larger than the value Pf0 set up beforehand, actuation is started as that by which plasma treatment was started (step 1). Maximum deltaCmax of fluctuation of the capacity of three variable capacitors with which the detector was built in the adjustment machine for every (every [in this case,] 5 seconds) fixed time amount, Fluctuation deltaPf of the progressive wave power signal Pf is checked (step 2), and detection processing of abnormality discharge is not performed noting that it is inside in the cases, such as immediately after ignition of the plasma, and a change of a processing step, when these fluctuation is larger than the values delta C0 and delta Pf0 set up beforehand (step 4). When that is not right, the plasma judges that it is in the condition (it is not the semantics that there is neither abnormality discharge nor instability) stabilized to some extent, and starts detection of abnormality discharge (step 5). As drawing 4 thru/or drawing 7 explained the reflected wave signal for 5 seconds first, it processes with a low pass filter 16, the Savitzky-Golay smoothing differential circuit 17, and the 2nd low pass filter 18 (steps 5, 6, 7, and 8),

and the signal 75 (signal finally used for detection of abnormality discharge) as shown in drawing 7 is acquired.

[0020] Subsequently, it considers as the criteria of decision of Maximum alpha (forward) and the minimum value beta (negative) of the signal 75 for [said] 5 seconds, and when Maximum alpha and the minimum value beta fill alpha>alpha 0 and beta<beta 0 to the values alpha0 and beta0 set up beforehand, fluctuation of a reflected wave considers that it is unusually large, and judges that it is abnormality discharge (steps 9 and 10). Here, it uses that they are alpha>alpha 0 and beta<beta 0 for decision of the existence of abnormality discharge because a reflected wave is "it increasing and decreasing" or the fluctuation pattern of a reflected wave with that peculiar to abnormality discharge of "a decrease increases." For example, when it merely decreases greatly for said 5 seconds throughout, beta<beta 0 is filled, but since alpha>alpha 0 is not filled, it can be judged as stable discharge (step 11).

[0021] In the flow chart shown in drawing 8 , although the existence of abnormality discharge was judged for every [which is called for 5 seconds] fixed time amount As shown in drawing 7 , after performing the first processing for 5 seconds first, as processing for [it comes to a degree] 5 seconds may be performed or it is shown in drawing 9 , processing which judges the existence of abnormality discharge continuously using the hysteresis of the signal by the time of day which went back for 5 seconds after a certain time of day may be performed.

[0022] When it is judged that abnormality discharge occurred by the abnormality discharge detector 19, the abnormality discharge detecting signal 21 is outputted to a control system 4. A control system 4 can suspend plasma treatment immediately. In

addition, also when it does not have serious effect to plasma treatment depending on extent of the generated abnormality discharge, for a certain reason, the wafer under processing may perform plasma treatment as it is, and may interrupt the plasma treatment of the wafer after a degree. Or you may give the alert for an alarm.

[0023] In the above explanation, although the reflected wave of the high-frequency power for plasma production was used as a signal for detecting abnormality discharge of the plasma, all the electric or optical signals of this invention that show a plasma treatment condition are available, without being limited to a reflected wave.

[0024] Moreover, as a signal for detecting abnormality discharge of the plasma, it can use combining the detecting signal from other means out of the reflected wave of the high-frequency power for plasma production.

[0025] For example, the signal 20 (signal which shows the capacity of a variable capacitor) which shows fluctuation of the impedance matching means 7 can be used. In this case, when extent of time fluctuation of the reflected wave of the detected high-frequency power is large and extent of time fluctuation of the signal 20 which shows fluctuation of said adjustment means is small, it can distinguish that abnormality discharge occurred.

[0026] Drawing 10 is drawing showing other operation gestalten. In addition, the same sign is attached about the same part as the part shown in drawing 1 in drawing, and the explanation is omitted. In plasma treatment equipment, in order to control the ion energy which carries out incidence to a processed material, RF generator 31 (it is hereafter called the power source for bias) other than the power source for plasma production is connected to the wafer stage 27 in which a processed material is laid through the

adjustment machine 30 for bias. In drawing 10 , it changes to the reflected wave of the high-frequency power for plasma production, and the signal concerning the peak voltage 32 of this power source 31 for bias, the DC component 33, and the power source for bias of reflective power 34 grade is supplied to the 1st low pass filter 16. A low pass filter 16, a differential circuit 17, and the 2nd low pass filter 18 supply these signals to the abnormality discharge detector 19, after performing a filter and differential processing. An abnormality discharge detector can detect the instability of the plasma, and abnormality discharge like the case where the reflected wave of the power for plasma production is detected, by using these signals, these signals, the signal 20 (signal which shows the capacity of a variable capacitor) which shows fluctuation of said impedance matching means 7, etc.

[0027] Moreover, plasma luminescence obtained by the photodetector 28 formed in the vacuum chamber is detected, and even if it carries out the spectrum of the plasma luminescence which detected through a spectrum and the signal magnification unit 29 and supplies a lightwave signal to an abnormality signal detector through the 1st low pass filter 16, differential circuit 17, and 2nd low pass filter 18 at this rate, it is possible to detect abnormality discharge of the plasma like the above.

[0028] Drawing 11 is drawing showing the operation gestalt of further others. In addition, the same sign is attached about the same part as the part shown in drawing 1 in drawing, and the explanation is omitted.

[0029] In drawing, as for the data collection section 25, the quantity of gas flow supplied to a vacuum chamber, power, gas pressure, etc. always collect process recipe data required for plasma treatment by receiving the process recipe data signal 26 from a

control system 4. Moreover, the signals which show fluctuation of progressive wave power, reflected wave power, and an impedance matching means are collected similarly.

[0030] The abnormality discharge detector 19 monitors all these data continuously. In the completely same process recipe, when the newly performed plasma treatment signals differ greatly to the hysteresis signal of these processing signals over the already processed wafer, this is detected, an abnormality signal is emitted to a control system 4, and it emits warning to delivery and a user. Or the plasma treatment of the wafer under processing activation or the plasma treatment of the wafer after the degree of the wafer under processing activation is suspended.

[0031] Although it is necessary to set up the suitable parameter (alpha0, beta0) for judging abnormality discharge beforehand in the example shown in drawing 1 In this example, process recipe data and a metaphor can perform detection or prediction of abnormality discharge generating, when the signal data in which fluctuation of reflected wave power is shown are stored and the historical data and the current line when performing normal processing compare the processing signal which is.

[0032] As explained above, the abnormality discharge accompanying deposition of the resultant to a vacuum chamber is promptly detectable. Moreover, based on this detection, plasma treatment can be interrupted and the poor plasma treatment resulting from the shift of particle, a charge-up damage, and a process etc. can be prevented. Therefore, the plasma treatment engine performance as the whole and the operating ratio of equipment improve, and detailed etching processing, quality membrane

formation processing, surface treatment processing, etc. are attained.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is drawing showing the plasma treatment equipment concerning the operation gestalt of this invention.

[Drawing 2] It is drawing showing the wave of the reflective power outputted from a directional coupler.

[Drawing 3] It is drawing showing the wave after detection of reflective power.

[Drawing 4] It is drawing showing the wave after detection when abnormality discharge occurs to the plasma.

[Drawing 5] It is drawing showing the wave after processing by the low pass filter.

[Drawing 6] It is drawing showing a primary differential signal.

[Drawing 7] It is drawing showing the wave of the signal used for distinction of abnormality discharge.

[Drawing 8] It is the flow chart which shows actuation of an abnormality discharge detector.

[Drawing 9] It is drawing explaining distinction of the abnormality discharge performed using hysteresis.

[Drawing 10] It is drawing explaining other operation gestalten.

[Drawing 11] It is drawing explaining the operation gestalt of further others.

[Description of Notations]

1 Plasma Production Means

2 Vacuum Chamber

3 Gas Installation Means

4 Control System of Plasma Treatment Equipment

5 Semi-conductor Wafer

6 Exhaust Air Means

7 Impedance Matching Box

8 High-frequency Power Generating Means

9 Directional Coupler

10 11 Detector circuit

12 13 Amplifying circuit

16 1st Low Pass Filter

17 Primary Differential Circuit

18 2nd Low Pass Filter

19 Abnormality Discharge Detector

22 Power-Source System

23 Plasma Treatment Equipment

25 Data Collection Section

27 Wafer Stage

28 Photodetector

29 Spectrum and Signal Magnification Unit

30 Adjustment Machine for Bias

31 RF Generator for Bias

DRAWINGS
